Purchasing power parity theory in three East Asian economies: New evidence

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Abstract:

To an otherwise extensive literature with yet mixed findings on the long run Purchasing Power Parity (PPP) theory, this paper extends the evidence *against* the PPP hypothesis in three East Asian economies namely Indonesia, Malaysia, and Thailand based on quarterly data spanning forty years (1968:Q1-2008:Q1). The testing of PPP hypothesis in this study employs two methods namely Engle-Granger procedure and Johansen multivariate cointegration method.

Keywords: Purchasing power parity, East Asian countries, Johansen multivariate cointegration test.

JEL code: C22, E29

1. Introduction

In spite of an already extensive literature with mixed findings either in favour or against the long run PPP theory, this paper offers a new evidence on the PPP hypothesis in the case of three emerging economies in the East Asian region namely Indonesia, Malaysia, and Thailand based on quarterly data that spans 40 years (1968-2008). The testing of PPP hypothesis in this study employs two methods namely Engle-Granger procedure and Johansen cointegration method.

The purchasing power parity (PPP) theory has a long history in economics. The general idea behind the theory is that a unit of currency should be able to buy the same basket of goods in one country as the equivalent amount of foreign currency, at the going exchange rate, can buy in a foreign country. This constitutes the "parity" between the purchasing power of the currency of two different countries. In absolute term, PPP demonstrates that the exchange rate, defined as the domestic price of foreign currency, should be equivalent to the ratio of the domestic price level to the foreign price level.

The equilibrium relationship implied in the absolute version of PPP assumes perfect commodity arbitrage[1] between the two countries in question. It is often expressed as:

$$E_t = \frac{P_t}{P_t^*} \tag{1}$$

where E_t is the domestic price of foreign currency, P_t is domestic price level and P_t^* is foreign price level. In the short run, the equilibrium relationship may not hold due to the shocks that may cause deviations from the PPP. Over the long run, however, one will expect that the shocks to diminish and neutralize and the equilibrium in the PPP relationship will be restored i.e. PPP holds in the long run.

[1]The mechanism in which the competitive markets in two trading countries equalize the price of identical goods, at the going exchange rate, in the two countries with the assumption of no transportation and other transaction costs.

In the empirical literature, the question of whether or not PPP hypothesis holds usually conducted by determining whether the real exchange rate, expressed as the relationship between the nominal exchange rate and relative prices, is stationary or not. With a slight modification to Equation (1), the real exchange rate can be represented as:

$$R_t = \frac{E_t P_t^*}{P_t} \tag{2}$$

or

$$r_t = e_t + p_t^* - p_t \tag{3}$$

where R_t is the real exchange rate, and r_t, e_t, p_t^* and p_t are the variables in logarithmic form. In other words, if the real exchange rate exhibits the tendency to return to its mean over the long run i.e. stationary, then it can be concluded that PPP equilibrium holds. On the other hand, PPP does not hold over the long run if the real exchange rate follows random walk.

On overall, the evidence from the empirical studies of PPP is rather mixed[2]. Empirical evidence supporting the theory can be found in studies, to name a few, Abuaf and Jorion (1990), Kim (1990), Glen (1992), Pippenger (1993), Becketti *et al.* (1995), and Su Zhou (1997). Whereas, the studies by Corbae and Ouliaris (1988), Baillie and Patrick (1989), Gan (1991), Flynn and Boucher (1993), and Chowdhury and Sdogati (1993) found evidence rejecting the hypothesis.

Baharumshah and Ariff (1997), Khoon and Mithani (2000) and Baharumshah *et al.* (2005) examined the PPP relationship in East Asian economies. The first two studies found evidence that the real exchange rate follows random walk i.e. PPP theory does not hold over the long run. The finding by Baharumshah *et al.* (2005), however, indicates strong

[2] For a more comprehensive surveys of the literature and debate on PPP, refer Rogoff (1996), and Taylor & Taylor (2004).

evidence supporting PPP for the Asian currencies in the post-Asian Financial Crisis era, but not in the pre-crisis.

This paper is organised as follows. This introduction is the first section, followed by Section 2 that briefly discusses methodologies and data sources. The estimation results are presented in Section 3 and Section 4 concludes.

2. Methodologies and data sources

In this paper, the analysis of PPP hypothesis employs two modelling approaches of the real exchange rate. Based on the Equation (1) above, Model 1 is expressed as the following:

$$e_t = \alpha_0 + \alpha_1(p_t) + \epsilon_t \tag{4}$$

where e_t is the nominal exchange rate or domestic price of foreign currency, and p_t is the ratio between the domestic and foreign price levels, ($\frac{P_t}{P_t^*}$), and all variables are in logarithmic form. Model 1 assumes symmetry and proportionality in the price levels of domestic and foreign countries but these assumptions may be restrictive at least for the industrialized economies[3]. The following is Model 2 that imposed no restriction based on Equation (3) with slight modification:

$$e_t = \alpha_0 + \alpha_1 p_t + \alpha_2 p_t^* + \omega_t \tag{5}$$

where e_t, p_t and p_t^* are the nominal exchange rate, domestic price level and foreign price level, respectively. The variables of interest in both models are the error terms ϵ_t and ω_t which explain the linear relationship between all other variables in the respective models. Since Model 1 is bivariate, the testing for cointegration in the two variables employs Engle-

[3] For further discussion on these assumptions, refer Baharumshah and Ariff (1997). Ardeni and Lubian (1989) showed that by using the more general specification i.e. without the restrictions, they were able to reject PPP.

Granger procedure. In the multivariate Model 2, Johansen cointegration test is also used in addition to the Engle-Granger procedure.

Introduced by Engle and Granger (1987), cointegration implies that between a number of non-stationary variable, there exists a linear combination among them that is stationary. This situation necessitates the time path of the non-stationary variables be linked which illustrates the crucial insight for the equilibrium theories. Within the equilibrium framework, the deviation from the equilibrium is said to be temporary in nature, and in the long run it will correct to its equilibrium level.

In the case of PPP, if the exchange rate, domestic and foreign price levels are all non-stationary and integrated of order one, I(1), and if the linear combination of them, i.e. the error terms in the Equation (4) and (5) are stationary, the variables are said to be cointegrated of order one, CI(1,1). The deviation from the PPP equilibrium is the error terms, and since $\{e_t\}$ and $\{\omega_t\}$ are stationary, it is temporary in nature and in the long run it will eventually diminish and the equilibrium in the PPP will be restored. A cointegrated system provides strong support for the absolute PPP, otherwise the process will tend to get larger over time and the exchange rate and price levels will diverge without bound.

As for the Engle-Granger procedure, the two-step procedure involves firstly to pretest the variables in the model for their order of integration. By definition, cointegration necessitates the variables be integrated of the same order. Augmented Dickey Fuller (ADF) test is used for this purpose. The ADF regression model of exchange rate variable is assumed to have only drift without time trend, whereas relative price level (in Model 1) and domestic and foreign price levels (in Model 2) are assumed to have a drift and time trend[4]. If both relative prices and nominal exchange rates are found to be integrated of the same

[4] The assumptions are made by investigating the graphical pictures of respective variables. Only drift can be spotted in the exchange rate graphs with no clear trend visible, and the trend and drift terms are both easily spotted in the price variables graphs. Refer Appendix for the graphs.

order, then the long run relationship between the variables as in the Equation (4) and (5) will be estimated.

In the second step, the residuals of the estimation are tested for unit root. The residuals represent deviation from long run equilibrium relationship, and for a PPP to hold over the long run, the residuals must exhibit a mean-reversion or stationary process in which the deviation will be corrected over the long run and the equilibrium is restored. The residual-based testing to determine whether null hypothesis of unit root in the residuals can be rejected utilises the following regression model:

$$\Delta\hat{\epsilon}_t = \phi\hat{\epsilon}_{t-1} + \sum_{j=1}^{n} b_j \Delta\hat{\epsilon}_{t-j} + v_t \quad (6)$$

with the white noise assumption of v_t and no constant and time trend. The appropriate critical values for residual-based testing from the cointegration regressions are given by Engle and Yoo (1987).

Besides, Johansen cointegration test is also employed as the testing methodology for the cointegration in the multivariate Model 2. Johansen and Juselius (1990)[5] maximum likelihood estimation can estimate and test for the presence of multiple cointegrating vectors. This test allows testing of restricted version of cointegrating vector(s) and speed of adjustment parameters. Johansen's procedure relies heavily on the relationship between the rank of a matrix and its characteristics root and considered as a multivariate generalization of the Dickey Fuller test. Test on number of cointegrating vectors is conducted using the following two test statistics, i.e. Trace statistics and Maximum eigenvalues statistics. Trace statistics tests the null hypothesis of number of distinct cointegrating vectors is at most

[5] Johansen (1988) tests for cointegrating relationship upon the VAR model of short run dynamics with only intercept in the cointegrating relationship but not in the VAR model, in Johansen and Juselius (1990), however, intercept is in both.

equal to *r* against a general alternative, while Maximum eigenvalue statistics tests the null hypothesis of number of cointegrating vectors is *r* against alternative of *r* + 1 cointegrating vectors (Enders, 1995). The critical values for both test statistics are provided by Osterwald-Lenum (1992) and are automatically generated by EViews 6. If the null hypothesis is rejected at any given *r* in both tests, they will be repeated until we fail to reject the null hypothesis.

The data sample spans for 40 years from 1968:Q1 until 2008:Q4[6] in quarterly observations expressed in natural logarithmic form. Nominal exchange rate is the period average market rate of national currency per U.S. dollar, whereas the Consumer Price Index[7] (2000=100) of the countries under study is selected to represent the domestic price level and U.S. CPI (2000=100) as the foreign price level. For Model 1, relative price is obtained by taking ratio of domestic CPI to U.S. CPI and taking log of the product. All series are obtained from International Financial Statistics database compiled by International Monetary Fund, and analyzed using the EViews 6 statistical package.

3. Estimated results

Table 1 below shows that the null hypothesis of unit root in the variables is overwhelmingly rejected in first difference but not in level. The ADF test thus concludes that all variables are non-stationary in level but stationary in first difference, i.e. all variables are I(1). Cointegration implies that there could be a stationary relationship between a number of I(1) variables. We then proceed with the estimation of the Model 1 of PPP long run equilibrium model. The estimation output and ADF test statistics of the estimated residuals are

[6] A sufficiently longer time period is needed to capture the long run relationship of PPP. Hendry (1986) points out that increasing the sample size by 'time aggregation' is unlikely to reveal the long run relationship. Some authors argued short horizon data may not be able to capture the performance of PPP because the time needed for PPP to re-establish for a pair of countries following any disturbance ranges from two to 10 years.

[7] More recent studies have used wholesale price index (WPI or PPI) instead of CPI because WPI is better proxy for the prices of tradable goods than the CPI. Data on WPI, however, available only from 1984 onwards for the countries under study which, if used, presumably could affect the outcome of testing.

presented in Table 2. The ADF test statistics however failed to reject the null hypothesis of unit root in the residuals. It can be concluded that there is no evidence of long run PPP hypothesis for Indonesia, Malaysia and Thailand.

Table 1: ADF test for unit root on the exchange rate and relative price

Variables / Countries	Exchange rate		Relative price	
	Level	First Difference	Level	First Difference
Indonesia	-0.26 (3)	-8.13 (2)**	-2.15 (1)	-7.86 (0)**
Malaysia	-1.38 (1)	-8.23 (0)**	-0.80 (5)	-4.46 (4)**
Thailand	-0.90 (3)	-8.49 (2)**	-2.85 (1)	-7.68 (0)**
Critical values	1% = -3.47 5% = -2.87 10% = -2.57		1% = -4.01 5% = -3.43 10% = -3.14	

Note: The null hypothesis is that the series contains unit root. Figures in parentheses indicate number of lags automatically determined by SIC. The critical values follow Dickey and Fuller (1976). *(**) indicates significant at 5% (1%) level.

Table 2: Estimation output and ADF test for unit root on the estimated residuals of Model 1

	Estimation output	ADF test statistics
Indonesia	$e_t = 8.74 + 1.46(p_t)$	-2.55 (1)
Malaysia	$e_t = 1.06 - 0.24(p_t)$	-1.67 (1)
Thailand:	$e_t = 3.56 + 2.21(p_t)$	-2.55 (1)
Critical values	-	1% = -3.73 5% = -3.17 10% = -2.91

Note: The null hypothesis is that the series contains unit root. Figures in parentheses indicate number of lags automatically determined by SIC. The critical values follow Engle & Yoo (1987).

As shown in Table 3 below, the similar result is obtained from the ADF tests for the variables in Model 2 where the null hypothesis of unit root in the exchange rate, domestic price and foreign price levels are strongly rejected in first difference but not in level, hence the variables are all I(1).

Table 3: ADF test for unit root on the exchange rate, domestic price and foreign price levels

Variables / Countries	Exchange rate		Domestic price level	
	Level	First difference	Level	First difference
Indonesia	-0.26 (3)	-8.13 (2)**	-1.34 (1)	-7.61 (0)**
Malaysia	-1.38 (1)	-8.23 (0)**	-1.88 (5)	-4.52 (4)**
Thailand	-0.90 (3)	-8.49 (2)**	-1.98 (1)	- 5.60 (0)**

US^	-	-	-3.01 (6)	-2.69 (5)**
Critical values	1% = -3.47 5% = -2.87 10% = -2.57		1% = -4.01 5% = -3.43 10% = -3.14	

Note: The null hypothesis is that the series contains unit root. Figures in parentheses indicate number of lags automatically determined by SIC. The critical values follow Dickey and Fuller (1976). *(**) indicates significant at 5% (1%) level.

^ US CPI is the foreign price level from the perspective East Asian countries.

The estimation output of the Model 2 regression and the ADF test statistics of the residuals are presented in Table 4. The positive sign for domestic price and negative for foreign price are correct as anticipated in the theoretical discussion earlier (refer Equation 3). Despite that, we are unable to infer that the absolute PPP hold because the parameters restriction (1, 1, -1) of the coefficients of variables ($e_t + p_t^* - p_t$) in the Equation (3) are yet to be tested. It can only be tested once we find evidence of the existence of at least one cointegrating relationship between the variables which suggests the weak-form PPP long run equilibrium. The ADF test results in the Table 4 below however indicate that we are unable to reject the null hypothesis of unit root in the residuals leading to the same conclusion that the PPP long run equilibrium in all countries under study does not hold.

Table 4: Estimation output and ADF test for unit root on the estimated residuals of Model 2

	Estimation output	**ADF test statistics**
Indonesia	$e_t = 7.41 + 1.28p_t - 1.00p_t^*$	-2.66 (1)
Malaysia	$e_t = -1.04 + 1.53p_t - 1.05p_t^*$	-2.47 (1)
Thailand:	$e_t = 2.67 + 1.29p_t - 1.10p_t^*$	-2.47 (1)
Critical values	-	1% = -3.73 5% = -3.17 10% = -2.91

Note: The null hypothesis is that the series contains unit root. Figures in parentheses indicate number of lags automatically determined by SIC. The critical values follow Engle & Yoo (1987, p.158).

We then proceed with the estimation of Vector Error Correction Model VECM (VAR model of short run dynamics) upon which the Johansen cointegration test is employed. All

variables in the Model 2 i.e. exchange rate, domestic and foreign prices are assumed to be endogenous since they are all I(1) with the optimal number of lag length set to 4 based on the evidence provided by Akaike's Information Criterion (AIC), and assuming intercept in both the cointegrating equation and the VAR model.[8] Table 5 below presents the results of Johansen and Juselius (1990) maximum likelihood estimation for the number of cointegrating relationship in Model 2 of PPP.

The results show that in all countries except Thailand, both trace and maximum eigenvalue tests clearly indicate that there is no cointegration between the variables at both 1% and 5% levels. For Thailand, mixed results are obtained as the trace test finds no cointegrating relationship in 1% level but three cointegrating relationships at 5% level. This finding should be treated with extra caution. If there are three cointegrating relationships between the three variables, then it is impossible for all variables to be I(1) individually as have been found by the ADF test earlier (Refer Table 3). Maximum eigenvalue test, however, indicates no cointegrating relationship at both 1% and 5% levels.

Table 5:Johansen cointegration test for Model 2

Country	H_0	H_a	Statis-tics	Critical values		Result
				95%	99%	
Indonesia	λ_{trace} test					
	$r = 0$	$r \geq 1$	15.52	29.68	35.65	λ_{trace} test indicates no cointegration at both 1% and 5% levels.
	$r = 1$	$r \geq 2$	6.56	15.41	20.04	
	λ_{max} test					
	$r = 0$	$r = 1$	8.95	20.97	25.52	λ_{max} test indicates no cointegration at both 1% and 5% levels.
	$r = 1$	$r = 2$	6.54	14.07	18.63	
Malaysia	λ_{trace} test					
	$r = 0$	$r \geq 1$	24.27	29.68	35.65	λ_{trace} test indicates no

[8] We also conduct Johansen cointegration test upon the VAR model of short run dynamics as suggested in Johansen (1988) i.e. with the presence of intercept in cointegrating equation only but not in the VAR model. We find no evidence of cointegration between the variables in the case of Indonesia and Malaysia for both Trace and Maximum Eigenvalues tests, For Thailand, one cointegrating equation is detected at 5% level of significance but none at 1% level in Trace test, whereas for Maximum eigenvalues test, no cointegration detected at both levels. The findings are almost identical to those reported below (using Johansen and Juselius (1990) VAR model with a constant term).

	$r = 1$	$r \geq 2$	10.15	15.49	20.04	cointegration at both 1% and 5% levels.
	λ_{max} test					
	$r = 0$	$r = 1$	14.11	20.97	25.52	λ_{max} test indicates no cointegration at both 1% and 5% levels.
	$r = 1$	$r = 2$	7.45	14.07	18.63	
Thailand	λ_{trace} test					
	$r = 0$	$r \geq 1$	34.59*	29.68	35.65	λ_{trace} test indicates no cointegration at 1% level, but 3 cointegrating equations at 5% level.
	$r = 1$	$r \geq 2$	15.7*	15.41	20.04	
	$r = 2$	$r \geq 3$	5.18*	3.76	6.65	
	λ_{max} test					
	$r = 0$	$r = 1$	18.85	20.97	25.52	λ_{max} test indicates no cointegration at both 1% and 5% levels.
	$r = 1$	$r = 2$	10.56	14.07	18.63	

*(**) indicates significant at 5% (1%) level.

Had the Johansen cointegration test finds evidence of at least one cointegrating relationship between the variables, then it can concluded that there is evidence of weak form PPP long run equilibrium for the countries under study, we can further proceed with testing of parameters restriction (1, 1, -1) of the coefficients of variables $(e_t + p_t^* - p_t)$ of the Equation (3). Since the Johansen cointegration test yields results of no cointegrating relation between the variables, to test the restricted model is then unwarranted.

4. Concluding remarks

This study examines whether the long run PPP equilibrium holds in East Asian emerging economies namely Indonesia, Malaysia, and Thailand by utilizing two long-run models of PPP with sample data spanning from 1968:Q1 until 2008:Q1. Two cointegration testing methodologies, namely the Engle-Granger procedure and Johansen cointegration test are employed.

Similar to findings by Baharumshah and Ariff (1997), Khoon and Mithani (2000), this paper finds no significant evidence to support the PPP hypothesis over the long run for the countries under study. Although the exchange rate and price levels are found to be non-stationary individually, there is however no long run relationship appears to hold between

them in each methodology tested. Baharumshah *et al.* (2005) however find evidence of PPP for post-AFC period but not in the pre-crisis period. It is possibly fixed exchange rate regime which was among the capital controls implemented by the Malaysian authority following the crisis that contributes to such finding by Baharumshah *et al.* (2005)

This study therefore provides additional evidence against PPP hypothesis for the countries under study and contributes to the existing literature particularly for the East Asian emerging economies especially that it covers sufficiently longer time periods. The Engle-Granger test is used in this study due to the fact the Model 1 is bivariate. The method, however, may draw major criticism in the multivariate model (Model 2) since this procedure is used to test for the null hypothesis of non-cointegration against one alternative only. Thus, Johansen cointegration test is used in the Model 2 testing as it provides estimate of all cointegrating vectors possible. With the emergence of numerous techniques for testing cointegration such as, to name a few, nonparametric rank tests and panel unit root tests, the evidence on the PPP long run relationship particularly in the East Asian emerging economies could be further improved.

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